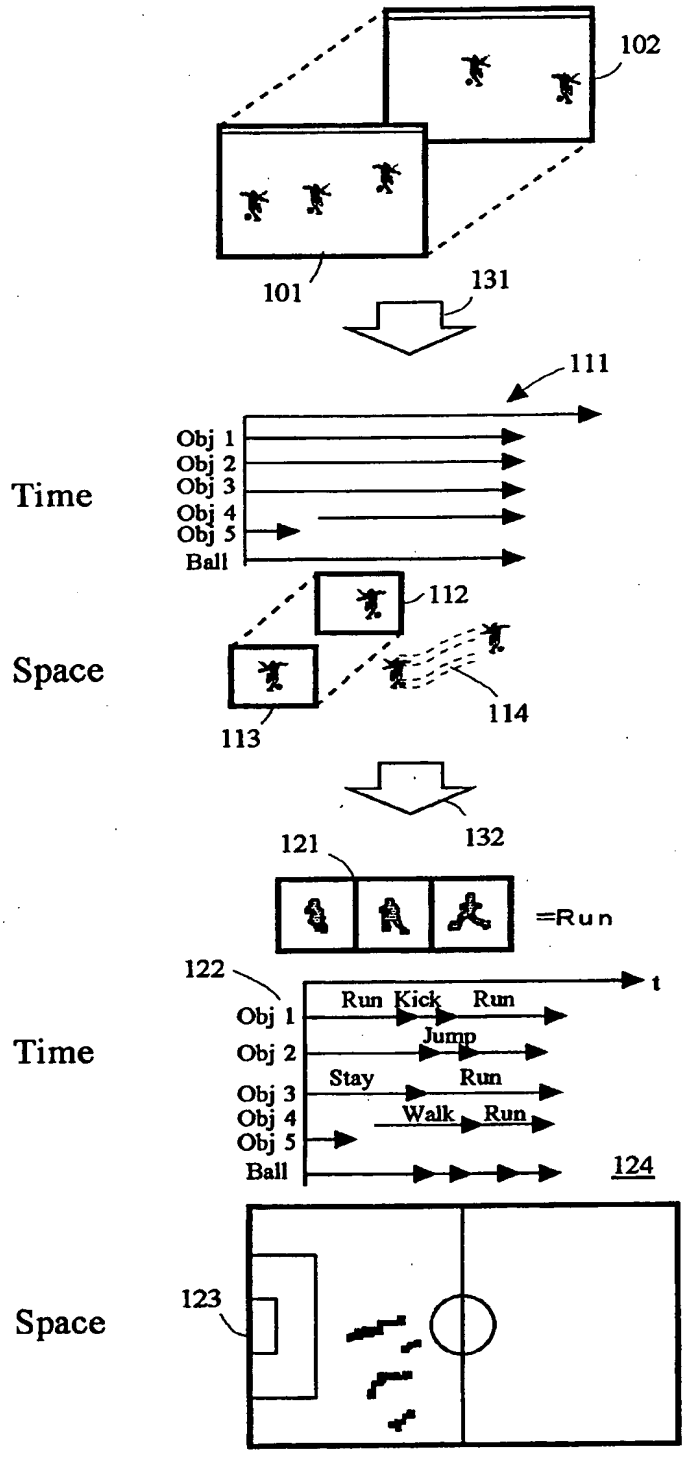
102
101
131
111
Time
Obj 1
Obj 2
Obj 3
Obj 4
Obj 5
Ball
112
Space
113
114
132
121
=Run
122
t
Time
Obj 1
Obj 2
Obj 3
Obj 4
Obj 5
Ball
Run Kick Run
Jump
Stay Run
Walk Run
124
Space
123

Fig. 1

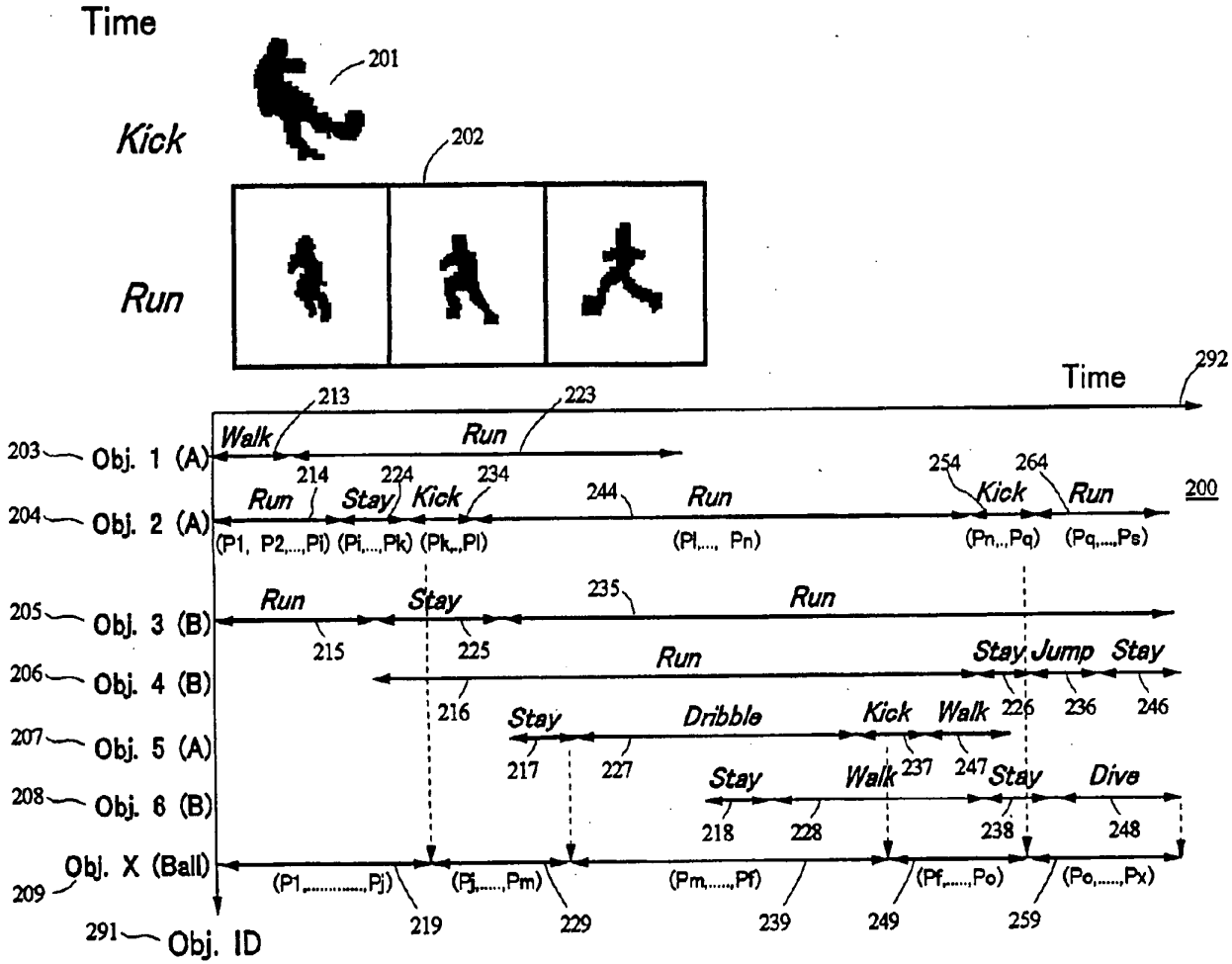

Fig. 2

09/890168

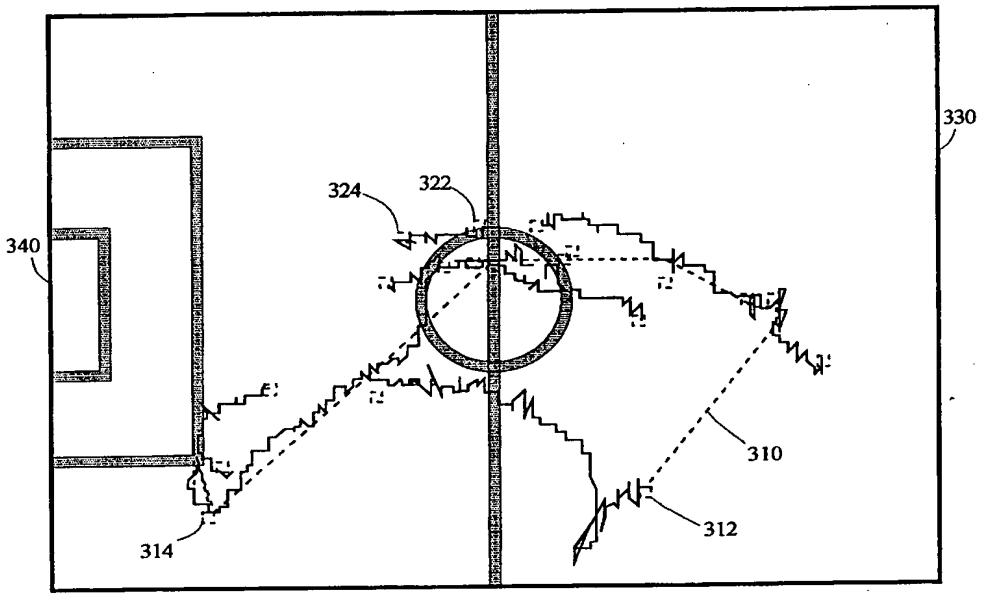

Fig. 3

Replacement Sheet

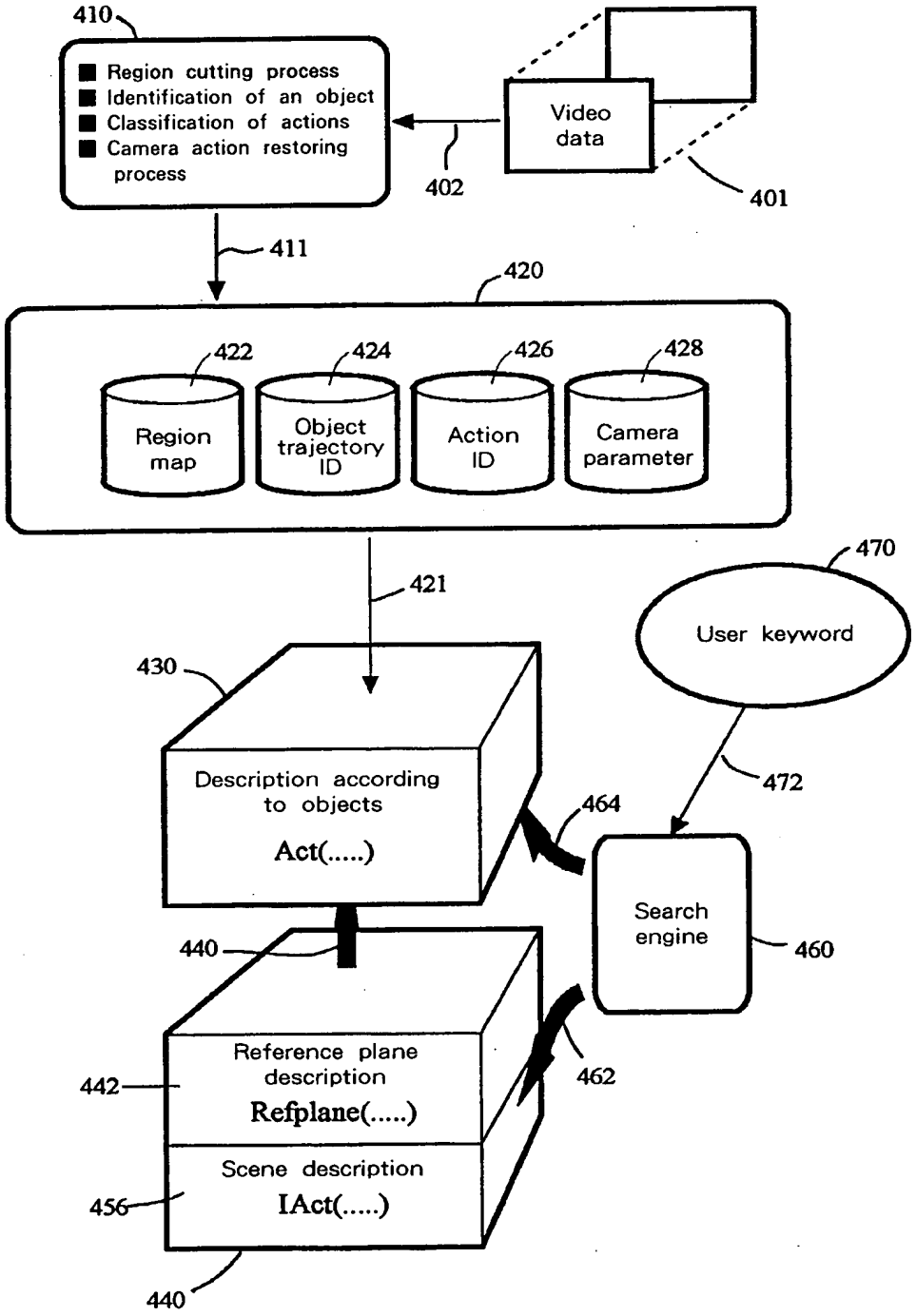
410
Region cutting process
Identification of an object
Classification of actions
Camera action restoring process
Video data
402
401
411
420
422
424
426
428
Region map
Object trajectory ID
Action ID
Camera parameter
421
470
User keyword
430
Description according to objects
Act(.....)
464
472
Search engine
460
440
Reference plane description
Refplane(.....)
462
442
Scene description
IAct(.....)
456
440

Fig. 4

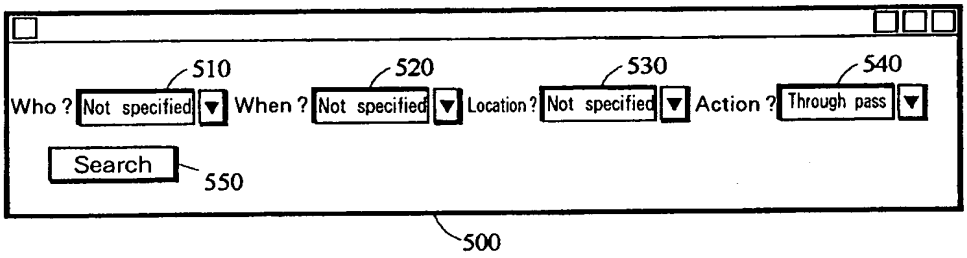
510
520
530
540
Who ?
Not specified
When ?
Not specified
Location ?
Not specified
Action ?
Through pass
Search
550
500

Fig. 5

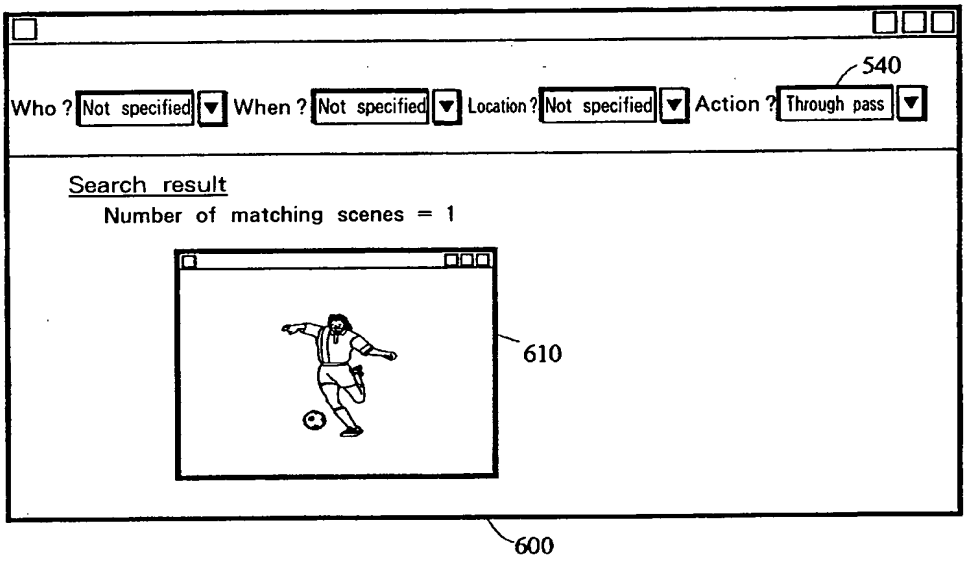
540
Who ?
Not specified
When ?
Not specified
Location ?
Not specified
Action ?
Through pass
Search result
Number of matching scenes = 1
610
600

Fig. 6

[Table 1]

Description of Reference plane:

Reference plane::= Model of the ground

<Ref ID>	text	----- Name of reference plane
<Plane>	cordinates	----- Center of the Area (e.g. (0,0))
<Metric>	array of numeric	----- define transformation (e.g. 3 × 3 matrix for Affine transformation)

Description of Zone Description:

Zone Description::= Define meaningful space on the ground

<Zone ID>	text	----- Identified the zone on the ground (e.g. Goal, Center line)
<Space>	space desc	----- define the space on the ground

Description of Camera Spec (option):

Camera Spec::= Define camera model

<Camera Type>	text	----- Identify camera model
<Param Array>	array of numeric	----- define model transformation

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[Table 2]

Description of Action:

Acrion:: Describe single player's action

<Action ID> text ----- Action Symbol (e.g. Run, Kick Walk, etc) (text representing types of actions)

<T-Interval> time interval ----- Time Interval of this action (represented by starting and ending times)

<Object ID> numeric ----- Object Identifier (object of this action)

<Trajectory> Time Stamped Polyline
(a line with a time attribute of each node) ----- Trajectory of the player in this action (trajectory of an object on reference plane in the time interval of this action)

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[Table 3]

Description of IAction:

IAction::= Meaningful event in the domain, composed of multiple players and ball

<IAction ID>	text	-----	Event Symbol (e.g. Shot, Pass, Through Pass, etc) (text representing types of events)
<T-Interval>	time interval	-----	Time interval of this action
<No of Object>	numeric	-----	Number of Objects
<Object ID>	array of numeric	-----	Array of Objects identifier
<Space>	Trajectory Polylines, Polygons	-----	Spatial description of this action

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[Table 4]

Definition of IAct:

begin

Definition of IAct
A list of an IAct, a child Act and a child ball (a child IAct and a child Act, etc. mean an IAct and an Act comprising this IAct)

where

[All the judgment parts and judgment statements with auxiliary functions are linked by AND]

fill

[An element assignment part of a defined IAct]

end

Here, variable symbols in a define statement have respective types which are represented by a first character of each variable. The types are as follows.

Type	Description
f	a frame
t	a time interval (consisting of starting and ending frames)
o	an object
O	a group of objects (consisting of a set of objects and the number of them)
p	a point (consisting of spatial component x and y)
P	a group of points (consisting of a set of points and the number of them)
A	a group of points, which means a polyline linking them
l	a time point (consisting of spatial component x, y and time component t)
L	a group of time points (consisting of a set of time points and the number of them)
i	an integer
d	a real number

[Table 5]

Line	Define statement	Description
1	begin	Beginning.
2	iact Through_pass t0 O0 L0	Here, it defines an Iact "Through Pass".
3	child_iact 1 Pass t1 O1 L1	Iact pass as one comprising this Iact.
4	child_act 3 Stay Walk Run t2 o2 false L2	And an Act of defense side player 1 (it means that a player with object ID o2 (Stayed, Walked or Ran) moving on trajectory L2 during time interval t2).
5		
6	child_act 3 Stay Walk Run t3 o3 false L3	An Act of defense side player 2.
7	where	
8	greater_than o2 o3	Two players of the defense side have different object IDs (their IDs are o2, o3).
9	get_object_from_GO o4 1 O1	Take the first player of Iact ("Pass") to put in variable o4.
10	not_same_team o4 o2	o4 and o2 are different teams.
11	not_same_team o4 o3	o4 and o3 are different teams.
12	set_length_of_polyline d0 L1	Length of a pass is measured.
13	less_than d0 20.0	Length of 20 m or less.
14	temporal_overlap t2 t3	Two players of the defense side have overlapping time intervals.
15	set_temporal_overlapping_period t4 t2 t3	The overlapping time intervals to variable t4.
16	temporal_overlap t1 t4	There is an overlap in time intervals of t4 and an Iact pass.
17	set_temporal_overlapping_period t5 t1 t4	Overlapping time intervals (consequently, overlapping Acts and Iact passes of the two players of the defense side) to variable t5.
18	get_frame_start_of_period f0 t5	Put a starting frame of time interval t5 in time point fO.
19	get_frame_end_of_period f1 t5	Put an ending frame of time interval t5 in time point f1.
20	set_ST_GL_dividing_point p0 L2 f0	The position (location) of player 1 of the defense side at time point fO to variable pO.
21	setS_ST_GL_dividing_point p1 L3 f0	The position (location) of player 2 of the defense side at time point fO to variable p1.
22	set_ST_GL_dividing_point p2 L2 f1	The position (location) of player 1 of the defense side at time point f1 to variable p2.
23	set_ST_GL_dividing_point p3 L3 f1	The position (location) of player 1 of the defense side at time point f1 to variable p3.
24	get_point_from_polyline p4 1 L1	The starting point of a pass to p4.
25	get_point_from_polyline p5 -1 L1	The ending point of a pass to p5.
26	Create_line P1 2 p4 p5	Create a line linking p4 and p5 (a pass course).
27	Create_line P2 2 p0 p1	A line linking pO and p1 (a line linking the two players of the defense side at time point fO).
28	Create_line P3 2 p2 P3	A line linking p2 and p3 (a line linking the two players of the defense side at time point f1).
29	spatial_cross P1 P2	P1 and P2 are crossing.
30	set_distance_point_and_line d1 p0 p4 p5	The distance from pass course pO at time point fO is sought.
31	set_distance_point_and_line d2 p1 p4 p5	The distance from pass course p1 at time point fO is sought.
32	less_than d1 7.0	The distance is 7 m or less.
33	less_than d2 7.0	Same.
34	spatial_cross P1 P3	P1 and P are crossing.
35	set_distance_point_and_line d3 p2 p4 p5	The distance from a pass course at time point f1 is sought as above.
36	set_distance_point_and_line d4 p3 p4 p5	
37	less_than d3 7.0	The distance is 7 m or less.
38	less_than d4 7.0	
39	fill	If the above conditions are met,
40	t0 t1	Assign the time interval of t1 (Iact pass) to tO (the time interval of an Iact through pass).
41	O0 O1	Assign the group of objects of O1 (Iact pass) to O1 (the group of objects of an Iact through pass).
42	L0 L1	Assign L1 (a trajectory of Iact pass) to LO (spatial representation of Iact through pass).
43	end	End.

[Table 6]

Line	Define statement
1	pass:
2	begin
3	Iact Pass t0 O0 L0
4	Child_act Kick|Jump|Sliding t1 o1 L1
5	Child_act Run|Stay|Walk t2 o2 L2
6	Ball t3 L3
7	where
8	same_team(o1,o2)
9	get_frame_start_period f1 t3
10	get_frame_end_period f2 t3
11	temporal_overlap t1 t3
12	temporal_overlap t2 t3
13	set_ST_GL_dividing_point p1 f1 L3
14	set_ST_GL_dividing_point p2 f2 L3
15	set_ST_GL_dividing_point p3 f1 L1
16	set_ST_GL_dividing_point p4 f2 L2
17	set_distance_point_to_point d1 p1 p3
18	set_distance_point_to_point d2 p2 p4
19	Less_than d1 0.5
20	Less_than d2 0.5
21	set_Go_from_objects O1 2 o1 o2
22	fill
23	t0 t3
24	L0 L3
25	O0 O1
26	End
27	
28	long pass:
29	begin
30	iact Long_pass t0 O0 L0
31	child_iact Pass t1 O1 L1
32	where
33	set_length_of_polyline d0 L1
34	Greater_Than d1 30.0
35	fill
36	t0 t1
37	O0 O1
38	L0 L1
39	end

FROM GOOGLE PATENTS

[Table 7]

Line	Define statement
1	feed pass:
2	begin
3	Iact Feed Pass t0 O0 L0
4	Child_Iact Pass t1 O1 L1
5	Child_act Run t2 o2 L2
6	where
7	get_object_from GO o3 -1 O1
8	same_object o2 o3
9	temporal_during t1 t2
10	fill
11	t0 t1
12	O0 O1
13	L0 L1
14	end
15	
16	cross pass:
17	begin
18	Iact Cross pass t0 O0 L0
19	Child_Iact Pass t1 O1 L1
20	where
21	get_frame_start_period f1 t1
22	get_frame_end_period f2 t1
23	set_ST_GL_dividing_point p1 f1 L1
24	set_ST_GL_dividing_point p2 f2 L1
25	set_length_of_polyline d1 L1
26	set_X_distance_point_and_point d2 p1 p2
27	greater_than d1 30.0
28	less_than d2 5.0
29	fill
30	t0 t1
31	O0 O1
32	L0 L1
33	end

[Table 8]

Line	Define statement
1	gain pass:
2	begin
3	Iact Gain_pass t0 O0 L0
4	Child_Iact Pass t1 O1 L1
5	where
6	get_frame_start_period f1 t1
7	get_frame_end_period f2 t1
8	set_ST_GL_dividing_point p1 f1 L1
9	set_ST_GL_dividing_point p2 f2 L1
10	set_length_of_Polyline d1 L1
11	set_Y_distance_point_and_point d2 p1 p2
12	greater_than d1 30.0
13	less_than d2 5.0
14	fill
15	t0 t1
16	O0 O1
17	L0 L1
18	end
19	
20	centering:
21	begin
22	Iact Cross pass t0 O0 L0
23	Child_Iact Pass t1 O1 L1
24	where
25	get_frame_start_period f1 t1
26	get_frame_end_period f2 t1
27	set_ST_GL_dividing_point p1 f1 L1
28	set_ST_GL_dividing_point p2 f2 L1
29	set_length_of_Polyline d1 L1
30	greater_than d1 8.0
31	set_X_distance_point_and_point d2 p1 p2
32	less_than d2 5.0
33	spatial_point_in p2,"Goal Area"
34	fill
35	t0 t1
36	O0 O1
37	L0 L1
38	end

[Table 9]

Line	Define statement
1	wall pass:
2	begin
3	iact 1-2_pass t0 O0 L0
4	child_iact Pass t1 O1 L1
5	child_iact Pass t2 O2 L2
6	child_act Stay Walk Run t3 o1 L3
7	where
8	get_object_from_GO o2 1 O1
9	get_object_from_GO o3 -1 O1
10	get_object_from_GO o4 1 O2
11	get_object_from_GO o5 -1 O2
12	not_same_team o1 o2
13	same_object o2 o5
14	same_object o3 o4
15	set_temporal_distance_period i1 t1 t2
16	Less_Than i1 5
17	not_same_team o1 o2
18	set_temporal_concatination_period t4 t1 t2
19	temporal_during t3 t4
20	get_frame_start_of_period f1 t4
21	get_frame_end_of_period f2 t1
22	get_frame_end_of_period f3 t4
23	set_ST_GL_dividing_point p1 L1 f1
24	set_ST_GL_dividing_point p2 L1 f2
25	set_ST_GL_dividing_point p3 L2 f3
26	Create_Area A1 3 p1 p2 p3
27	set_ST_GL_dividing_point p4 L3 f1
28	set_ST_GL_dividing_point p5 L3 f3
29	spatial_point_in p4 A1
30	spatial_point_in p5 A1
31	set_ST_GL_concatinate_polyline L4 L1 L2
32	fill
33	t0 t4
34	O0 O1
35	L0 L4
36	end

[Table 10]
List of group of auxiliary functions:
(1) Functions suitable for soccer
same_team (Player0, Player1)
same_team (Player, Location)
It shows whether Player0 and Player1 belong to the same team.
One of them may represent a position such as "GOAL."

(2) Functions that generally hold apart from soccer

#	[Temporal]	
1	get_frame_start_of_period (f1,t1)	Assign the starting point of time interval t1 to f1.
2	get_frame_end_of_period (f1,t1)	Assign the ending point of time interval t1 to f1.
3	set_period_from_frames (t1,f1,f2)	Create time interval t1 from two time points f1, f2.
4	get_period_of_GL (t1,L1)	Assign the lifetime interval of trajectory L1 to time interval t1.
5	temporal_in (f1,t1)	Time point f1 is inside time interval t1.
6	temporal_meet (t1,t2)	t1 and t2 exist in this order, and ending point of t1 and starting point of t2 are the same.
7	temporal_overlap (t1,t2)	There is a time interval overlapping time intervals t1 and t2.
8	temporal_start (t1,t2)	Time intervals t1 and t2 have the same starting point.
9	temporal_finish (t1,t2)	Time intervals t1 and t2 have the same ending point.
10	temporal_during (t1,t2)	Time interval t1 is completely included in time interval t2.
11	temporal_equal (t1,t2)	Time intervals t1 and t2 have the same starting and ending points.
12	temporal_before (t1,t2)	Time interval t1 ends earlier than the starting point of t2. No overlapping time interval.
13	set_temporal_overlapping_period (t1,t2,t3)	Assign the overlapping time intervals of t2 and t3 to t1.
14	set_temporal_concatination_period (t1,t2,t3)	Assign the concatenated time intervals of t2 and t3 to t1.
15	set_temporal_distance_period (i1,t2,t3)	Assign the difference between ending point of time interval t2 and starting point of t3 to i1.
16	set_ST_GL_dividing_locus (L1,t1,L2)	Assign to L1 the trajectory of a part applicable to partial interval t1 of the lifetime interval of trajectory L2.
17	set_ST_GL_concatinate_locus (L1,L2,L3)	Assign to L1 the trajectory concatenating trajectories L2 and L3.
	[Spatial]	
18	set_ST_GL_dividing_point (p1,L1,f1)	Assign the position of trajectory L1 at time point f0 to p1.
19	set_point_from_locus (p1,l1)	Convert a point l1 of trajectory data to position data p1.
20	set_point (p1,i1,i2)	Define position p1 of which x, y coordinates are i1, i2.
21	Create_Polyline (P1,i1,p1,p2,...)	Create line P1 linking point sets made up of p1, p2, ...(the number, i1).

[Table 11]
(2) Functions that generally hold apart from soccer (continued)

#	[Temporal]	
22	Create_Area (A1,i1,p1,p2,...)	Create polyline A1 linking point sets made up of p1, p2, ...(the number, i1).
23	set_length_of_polyline (d1,X1)	Assign the length of the line shown by X1 to d1. X1 is P or L.
24	set_deistance_point_and_point (d1,p1,p2)	Assign the Euclid's distance between positions x1 and x2 to d1. x is p or 1.
25	set_X_distance_point_and_point (d1,x1,x2)	Assign the distance on axis x between positions x1 and x2 to d1. x is p or 1.
26	set_Y_distance_point_and_point (d1,x1,x2)	Assign the distance on axis y between positions x1 and x2 to d1. x is p or 1.
27	set_distance_point_and_line (d1,x1,P1)	Assign the distance between position x1 and line P1 to d1. x is p or 1.
28	set_distance_point_and_Area (d1,x1,A1)	Assign the distance between position x1 and polyline A1 to d1. x is p or 1.
29	spatial_point_in (p1,X1)	Position p1 is included in X1. X is P or A.
30	spatial_line_in (P1,A1)	Line P1 is completely included in polyline A1.
31	spatial_apart (P1,P2)	No overlap of two lines p1 and p2.
32	Spatial_line_touch (P1,X1)	There is a shared point between P1 and X1. X is P or A.
33	spatial_through (P1,A1)	P1 is penetrating polyline A1.
34	spatial_overlap (A1,A2)	Two polylines A1 & A2 are partly overlapping.
35	spatial_contain (A1,A2)	A1 is completely included in A2.
36	spatial_area_touch (A1,A2)	A1 and A2 are touching at a point or a line.
37	spatial_disjoint (A1,A2)	No shared part between A1 and A2.
38	spatial_cross (P1,P2)	Two lines P1 and P2 are crossing.
	[Object handling]	
39	same_object (o1,o2)	Two objects o1 & o2 are the same objects.
40	not_same_object (o1,o2)	Two objects o1 & o2 are different.
41	get_object_from_GO (o1,i1,O1)	i1-th element of set of object O1 is o1.
42	set_GO_from_objects (O1,i1,o1,o2,...)	Create object set O1 from o1, o2....
43	get_number_from_GO (i1,O1)	To i1 seeking the number of elements of object set O1.
	{Numerical}	
44	greater_than (x1,x2)	x1 > x2, x is f, d, o.
45	less_than (x1,x2)	x1 < x2, x is f, d, o.
46	equal (x1,x2)	x1 = x2, x is f, d, o.